Introduction to Semantic Role Labelling

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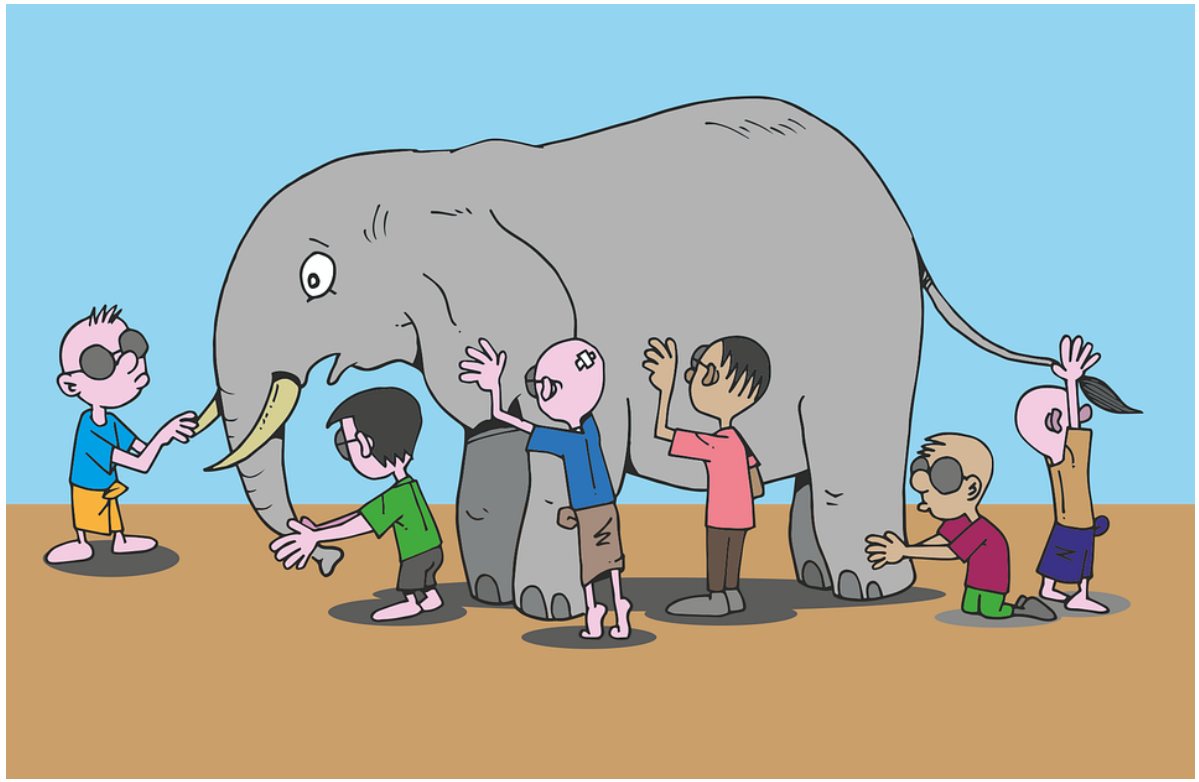
Today's Intro to Semantic Role Labelling!



"Reality is one, though wise men speak of it variously."

Elephant is natural language semantics, and the blinds are wise man studying it.

Today's Intro to Semantic Role Labelling! (contd.)

The story of 4 travelers and the grape!

A Persian, a Turk, and Arab and a German were traveling. They spent all their money except one last Euro coin. They were all hungry and wanted to buy food. With the coin, the Persian wanted 'Angur'; the Turk, 'uzum'; the Arab, 'anab'; and the German, 'Traube'. They started to argue for what they desired.

A **linguist** passing by and heard their quarrel. "Give the coin to me," he said and I will solve the problem. So, the linguist went to a nearby shop and bought four small bunches of grapes. He then returned to the men and gave them each a bunch.

"This is angur!" the Persian said. "But this is uzum," the Turk said. "Great, this anab," the Arab said. "No! I call this Traube." Suddenly, the travelers realized that they all wanted the same thing, only they used different words to communicate.

In semantic role labelling, linguists, sometimes act like the travelers of our story.

Some Basic Definitions: Argument structure

It is likely that you are aware of the meaning of predicate-argument-structure (or, simply argument-structure) and valence; but we review them anyway.

Take the following as an example

(1) John loves money.

Some Basic Definitions: Argument structure (contd.)

'to love' is a concept that binds two arguments (concepts, one being John and another money) together in a way that is dictated by love:

> John is the lover,
>
> money is the thing that John has a 'burning desire' for it,
>
> and that this burning desire has some connotations/effects that is best described as a love relationship between the two things (John and money).

Some Basic Definitions: Argument structure (contd.)

In linguistic literature, this main event (i.e., love relationship or simply love) is called predicate and the objects that involved in this event/predicate named arguments;

The arguments are usually labelled with a (semantic) role label from a vocabulary (a predefined set) which we will study some of them in our course.

Some Basic Definitions: Argument structure (contd.)

The predicate-argument structure in our earlier example

John loves money.

can be presented as:

love:<Agent, Patient>

or, equally as

love:<Agent=John, Patient=money>

Some Basic Definitions: Argument structure (contd.)

Here, Agent and Patient are from the vocabulary defined in our meta-language (so we have to look into the semantics of our meta language to understand what they mean).

Particularly for syntacticians, the representation love:<Agent, Patient>is called theta-grid (mostly generative grammar clad). Also, they use the term Theta Role to call (what we called earlier) Semantic Roles (theta roles were invented mainly to stay away from problems attached to semantic roles). The theta grid here indicates that love assigns two theta roles. For syntactic usages, the theta grid for a word (here love) is attached to it in a lexical knowledge-base.

Some Basic Definitions: Argument structure (contd.)

The predicate-argument structure is assumed to be important based on the hypothesis that they carry crucial information concerning syntactic and semantic realizations of their content.

An argument-structure typically indicates the number of arguments a predicate takes, their syntactic expression, and their semantic relation to predicate and with each other wrt. their predicate (Adjuncts are discarded; we get to it!).

In many studies, predicate-argument structures are the blueprints for logic propositions; e.g., to assess their truthfulness or/and assert them as facts (often predicate calculus used). This is well behind the scope of this course.

Some Basic Definitions: Argument structure (contd.)

Argument structure and Semantic Role Labeling:
In semantic role labeling, we are aiming to build a machine-readable/structured representation of these structures. To achieve this goal, we devise a meta-language and we use it for describing predicate-argument structures. This is done with the hope that they can be used to assess the truthfulness of natural language statements (attend the Semantic Parsing course).

Two questions: Is there a universal meta-language? No.

Are there commonalities between them? Yes.

Some Basic Definitions: Valency

The second idea that we want to touch on is valency or valence.

The idea is borrowed and similar to what we studied in our general Chemistry course: We assumed that elements have a valency (depending on the configuration of electrons in electron shells etc.), e.g., we have been thought that Carbon has 4 valence and Oxygen 2 and, which used to explain the formation of CO_2 (Carbon dioxide) as:

$$:\ddot{O}: \quad + \quad :C: \quad + \quad :\ddot{O}:$$

which gives us the structure O=C=O.

Some Basic Definitions: Valency (contd.)

By analogy with the "valance" idea in chemical compounding, lexical valency shows the capacity/desire of words to combine with each other. That is, valence/valency shows the capacity of a predicate (mostly verbs) to govern/control arguments.

The idea is mostly attributed two Lucien Tesnière, a French linguist who used the idea in the context of Dependency grammar (grammatical relations between pairs of words, no phrasal constituents in its syntactic analysis).

Some Basic Definitions: Valency (contd.)

Tesnière suggested that words are connect to each other (collocations are habitual) and these connections form a sentence. He supposed a verb is like an "atom with bond" and it engages differently with actants (dependants of the verb); and that the valence of the verb is decided by its bond! and so on ... (valance types are typified etc.).

In grammar frameworks such as dependency grammar (lexical-driven parsing, LFG etc.), the notion of valency is central as it is the main source of knowledge for forming the subsequent syntactic analyses (the premise for conclusion).

Some Basic Definitions: Subcategorization

and Subcategorization frames

Subcategorization frame is a formal presentation of subcategorization information regarding words, mostly verbs. Subcategorization proposed in 1960s in the context of transformational grammar, which came out of the Generative Grammar theory. Chomsky (1965)'s *Aspects of the Theory of Syntax* is often cited as the source for subcategorization.

Some Basic Definitions: Subcategorization (contd.)

and Subcategorization frames

The idea is very similar to valency, with an emphasis on syntactic arguments (phrasal structures). That is, subcategorization argues that words require/allow the company of certain syntactic arguments. For instance, for noun 'orange' we do not expect a particular company (except determiner) to furnish its meaning but for a transitive verb we expect two NPs one as subject, the other as object.

Some Basic Definitions: Subcategorization (contd.)

and Subcategorization frames

In other words, to generate a sentence that conveys an intended meaning, words alone (even a meaningful combination of them) are not sufficient, and that words must appear in certain order and within certain type of grammatical structure licensed by the verb (or words).

(2) a. John bought his wife a flower.
b. *John bought a flower his wife.

(2-b) is incorrect although it contains the combination of words in (2-a).

Some Basic Definitions: Subcategorization (contd.)

and Subcategorization frames

Subcategorization frames formalize constraints/information regarding syntactic behaviours exemplified above (simply put, rules). For instance,

give: V, [NP_ _NP]

to say that the verb 'give' requires two NPs at its children.

hit: V, [NP_ _(NP)]

to say that the verb 'hit' requires one NP and allows for another optional NP.

Precise systems for expressing these types of information can be found in syntax realm, e.g., Chomsky (1965).

Some Basic Definitions: Subcategorization (contd.)

and Subcategorization frames

In the context of semantic role labeling, subcategorization frames are important:

> The hypotheses regarding subcategorization and meanings, e.g., words of similar meaning have similar subcategorization frames (the same pattern in their syntactic realization).
>
> They are used as features in automatic semantic role taggers.

Some Basic Definitions: Arguments vs. Adjuncts

For the purpose of our future analysis, we must be able to distinguish between adjuncts and arguments.

Adjunct are assumed to be *supplementary*/*secondary* part of an predicate-argument structure rather than an *essential*.

By contrast, arguments are essential and obligatory elements of a sound and complete proposition (the logical structure w aimed at in our analysis).

Some Basic Definitions: Arguments vs. Adjuncts (contd.)

Distinguishing between adjuncts and arguments, or in other words to identify essential elements of our proposition is not easy since we do not have a solid ground for it (e.g., syntactic forms).

For distinguishing adjuncts and arguments, different strategies have been proposed and employed, e.g., you can find online a questionnaire-based mechanism used for the Prague Semantic Dependency project. For this purpose, Xue suggests a number of criteria:

Some Basic Definitions: Arguments vs. Adjuncts (contd.)

I. Arguments tend to co-vary with the predicate while adjuncts do not. That is, one predicate demands a set of arguments which are often different than another predication.

In other words, adjuncts are commonplace wrt. to their predicate (i.e., they appear frequently with many different predicates, the example of Time and Location). In contrast, arguments are essential only to a handful of predicates, e.g., Food.

Some Basic Definitions: Arguments vs. Adjuncts (contd.)

II. The absence of arguments can be sensed. For instance, in

(3) I ate.

while the sentence is 100% correct, one still expects for the missing argument Food. This expectation is different than, for instance, time or location adjuncts. While we expect that the event of *eating* has occurred at some Place and some specific time, their absence does not impact the meaning (our proposition) as the missing argument Food.

Some Basic Definitions: Arguments vs. Adjuncts (contd.)

III. Arguments are unique in the sense that we do not expect multiple arguments fills the same role and have the same semantic relationship with the predicate: be careful not to misinterpret it based on a NP that contains conjunction:

(4) I ate Currywurst and Pommes frittes.

Above, *Currywurst and Pommes frittes* is one noun phrase. But, consider:

Some Basic Definitions: Arguments vs. Adjuncts (contd.)

(5) In Germany, I ate Currywurst and Pommes frittes, in Fritten Piet, in Düsseldorf-Stadtmitte.

In Germany and *in Düsseldorf-Stadtmitte* and *in Fritten Piet* are three different prepositional phrases.

Re-Introduction

Mostly recap from the first session

Analysis of semantic relations and predicate-argument structure, what does it mean?

We have robust syntactic parsers that can tell us what is the subject, object, etc. in a sentence.

But, the syntactic analyses from these parsers do not tell us much about the the full meaning of sentences. That is, syntactic parses do not tell us Who did What to Whom, How, When, Where, and Why?

Semantic role labeling (SRL) wants to solve this problem.

Re-Introduction (contd.)

One may simply define semantic role labeling as categorizing the arguments of predicates to a number of predefined classes, each class representing a *type* of participant.

> Obviously, this definition depends on your expectation from the structure of predicate-argument structure (does it contain theta roles?). Similar definitions can be proposed using subcategorization and valency.

Anyway, to answer "Who did What to Whom, How, When, Where, and Why?" we must identify events and their participants from their descriptions in natural language.

Let's continue with an example.

Re-Introduction (contd.)

For instance, for sentences such as

(6) a. John gave a flower to Mary in the restaurant.
b. In the restaurant, John gave Mary a flower.

we are looking for analysis such as

> We are dealing with (let's call it) a Giving event.
>
> and, that in this Giving event
>
> > John is the Agent,
> > Mary is the Recipient, and
> > flower is the transferred Item;
> > additionally, the event took place in restaurant, i.e., a Location

Re-Introduction (contd.)

This description of the event gives us a list of conceptual relations (which we can call them semantic role, too) between the things noun phrases are referring to (we call them referents) with respect to the verb give: conceptual relations between referents with respect to event Giving.

We arrived to the above analysis through a relatively simple steps but if you keep doing this process for a few more sentences, you will experience a number of setbacks (and specially if you think of computers).

Re-Introduction (contd.)

For instance, with respect to the syntactic structure of sentences

1-to-many relationship between a role and syntactic form: the same conceptual relation can be described by different syntactic structures/constituents (see Mary above), and

many-to-1 relationship between several roles and a syntactic form: different semantic roles expressed using the same syntactic structure/constituent

Re-Introduction (contd.)

These 1-to-n, and n-to-1 relationships between meanings and forms have formed many topics of study in philosophy, semiotics,etc. Similarly, in linguistics, analysis of meaning with respect to syntactic forms have formed a central topic:

Linking Theory:

> *. . . mapping from the syntactic analysis of the sentence to the underlying predicate argument structures (. . . known as Linking Theory).*

Re-Introduction (contd.)

In following example (7), which is discussed in our first meeting (also in our previous example (6)):

(7) a. The boy broke the window.
b. The window broke.

in both sentences, we can call 'window' the Patient of the event Breaking and 'boy' as the Agent or Causer of the event.

But consider the syntactic analysis of these sentence:

a the 'window' is the direct-object of broke, and

b the 'window' is the subject of broke

Re-Introduction (contd.)

the syntactic analysis does not tell us that in (7-a) and (7-b) the same conceptual relation with respect to event/verb is expressed; ✗

i.e., the same conceptual relation is expressed using different syntactic structures. ✗

not only that, syntax won't tell us that *The hammer broke the window.* is different (semantically) than (7-a). ✗

In a little more precise language, in the first case (7-a) we have a transitive verb while in the second sentence (7-b) we have an intransitive verb in which the Patient has replaced the Agent. This is, probably, in contrast to our expectation that the Patient will be dropped from the intransitive verb.

Re-Introduction (contd.)

Maybe you still say "Das ist einfach!" (e.g., we use a dictionary and count the arguments of verb to decide between transitive and intransitive).

But, NO! it is complex since the alternation shown above is not applicable to every transitive verb: transitive verbs usually maintain the same semantic role for their subject (the expected behaviour) while some verbs such as *break* do not.

More definitions: Transitive Verbs, Diathesis Alternation

Intransitive verb: a verb that does not take a direct object.

Transitive verb: a verb that requires one or more objects (ditransitive requires two objects; tritransitive requires three objects and so on.).

Diathesis alternation: when a verb can be used in different subcategorization frames or with different valency (e.g., both as intransitive and transitive).

RE-Introduction (contd.)

Syntax and Semantics are in a complicated relationship!

Just to convince you further regarding the 'complicated' relation between syntax–semantics, look at the next few examples (most are from our text book Palmer et al. (2010)).

First, consider the following sentence—wrt. (7)—which is incorrect and cannot be used:

(8) *John breaks

so, John breaks what?!! (between, the * marks ungrammatical examples).

RE-Introduction (contd.) (contd.)

But in contrast we have the play verb which can be used as an intransitive and transitive verb and it can additionally move its Theme to the subject position:

(9) a. John played taps.
b. John played.
c. Taps played quietly in the background.

Furthermore, can play play with Instrument such as:

(10) John played bass guitar for the first time.

Can we imagine more alternation?

RE-Introduction (contd.) (contd.)

Syntax and Semantics are in a complicated relationship, and, they have a child called semantic role, trapped in between.

Besides all the puzzling questions regarding alternation patterns for *break* and *play*; what is the semantic relationship between *play* (our predicate) and *bass guitar*: Theme or Instrument, or something else?

Why guitar is not Theme? Use the alternations for Theme, does it work? Can we group Instrument and Theme and make InstroTheme role? If YES, why? If no, WHY?!

Questions like these might be answered in the next few weeks.

Bibliography

Palmer, M., Gildea, D., and Xue, N. (2010). *Semantic Role Labeling*. Synthesis Lectures on Human Language Technologies. Morgan & Claypool Publishers.